

## DUST STORMS, NOVEMBER 1933 TO MAY 1934

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The great dust storm of May 9-12, 1934 aroused such interest in its extent and intensity that the Weather Bureau circularized its stations east of the Rocky Mountains to obtain detailed reports of that and other similar storms. The reports are summarized below.

Dust storms cause much discomfort to human beings and animals through inhalation of the drifting particles, and also deposit much dirt generally. Their major damage, however, is the removal of productive topsoil from agricultural regions, however much the removed soil may benefit another region where it may be deposited. In parts of the Great Plains area the transportation of soil was of such magnitude as to strip the fields of tillable soil down to plow depth. Indeed, the wind-borne dust that covered the country this last year represents untold millions of dollars in productive soil that cannot be replaced. It has been claimed that the dust storm adds to the productiveness of soil elsewhere, but that is cold comfort to a Great Plains farmer who has seen the seed blown out of the ground by the wind and has had his fertile soil blown into drifts by the wind, or entirely removed.

The following is an extract from an article for the 1935 Department of Agriculture Yearbook, prepared by the Forest Service:

Soil erosion by wind has been more destructive throughout the Great Plains region during 1933 and 1934 than for any other similar period since the native sod was broken for crop production. Millions of acres are subject to wind erosion, and from hundreds of thousands of acres of level to slightly rolling land the soil was blown as deep as the fields had been tilled the previous year. Fences, Russian thistles, weeds, shrubs, farm machinery in the fields, farmsteads, windbreaks, roads, or any obstruction that might retard the wind velocity and permit the soil to settle were filled or covered with wind-blown soil.

The principal causes of the disastrous soil blowing in 1933 and 1934 were continuous high winds, intensive cultivation, the practice of burning stubble, low rainfall, and lack of organic matter to hold the soil in place. The loam and light sandy soils are subject to blowing. Under the same conditions the light, sandy soils will usually blow before the heavier loams.

The first sign of soil blowing is a little dust arising from a small portion of the field. Later the dust will come from a larger area, and if control measures are not begun promptly, all the field will eventually be blowing.

During the period under consideration there were 5 major dust storms, considering only those that overspread a considerable section of the country. In addition, there were many that were confined to a rather limited portion of the Great Plains and adjacent sections.

The first great storm occurred on November 12-13, 1933, when dust was reported from Nebraska to Georgia and New York. The second of these was on April 9-12, 1934, with dust noted from the Dakotas to Florida. The third followed soon after on the 18-20th of the same month, with dusty conditions ranging from the Dakotas southeastward to western North Carolina. The fourth major storm was on April 21-24, 1934, when dust was noted from the Dakotas to eastern Tennessee. The next was the most widespread of them all, occurring on May 9-12, with dusty conditions reported from all sections east of the Great Plains, except along the Gulf coast and in Florida.

During November 1933 there were 38 reports from first order Weather Bureau stations of dusty conditions; during December only 1, January 10, February 25, March 18, April 179, and May 182. The storms during

May were largely confined to 4 or 5 days around the 11th, but during April they were more general, with dust noted in some part of the country on all but 4 days of the month.

The following are extracts from reports furnished by the section directors of the Weather Bureau in the States most seriously affected.

*Huron, S. Dak.*—The number of days with dust storms that involved practically the entire State was 60 for the 5-month period, January to May, 1934. Agriculture, of course, has sustained the greatest losses. In the eastern half of the State, where small grain cultivation predominates, every farm has been injured, more or less, by soil erosion, destruction of fences, injury to buildings, loss of crops, and the depletion of herds and other stock. The total losses to agriculture, transportation, and business, is estimated at 200 million dollars. April 18-23. Dust storms continued to prevail with great severity. (See fig. 1.) Farm work at a standstill, agriculture demoralized by continued drought and almost daily occurrence of dusty weather and blowing of soil. Enormous losses to winter grains and early seeded crops. The storm of the 21st was so severe that darkness came on at 4:36 p. m. and continued until 5:56 p. m. during which time lights were required. Visibility was reduced to only 50 feet.

*Bismarck, N. Dak.*—While frequent dust storms have visited North Dakota this spring (1934), those on 11 days warrant special mention. The most severe of these storms occurred on April 21 and 22. The velocity of the wind was greater on the 21st, but the volume and density of the dust was greater on the 22d. The latter storm caused the most comment because of the fact that the 22d fell on a Sunday, and travel both by automobile and by plane was hazardous and difficult. Several aviators reported that dust was encountered at all levels up to 14,000 feet. A report on the storm of April 22 follows: A severe dust storm began at 11 a. m. and continued all day, ending the night following. Visibility at the station was as low as 200 yards, at various times. This was the most severe dust storm experienced at the Bismarck station during the 28 years that I have been in charge.

*Lincoln, Nebr.*—The presence of dust in the air is not rare in Nebraska, especially during dry periods in February, March, and April. During the present season (1934) the dust storms have been more numerous than usual, more general in character, and have extended into May, which ordinarily, except for June, is the wettest month of the year. Dust was recorded during March somewhere in the State on 11 different days, and on two separate occasions, the 13th and the 16-17th, was general and severe, obscuring the sun at times. During April, dust occurred on 21 days, and on the 10-11th it was dense enough to obscure objects at a distance of 1,000 feet in many places.

*Topeka, Kans.*—At Topeka the dust storms of April 11 and 23, 1934, were the worst in many years. On these days the sun was obscured at times by dust and in the evenings illumination from street lights was materially dimmed. It would seem that these dust storms (a kind not at all uncommon in western Kansas during prolonged dry periods, especially in spring when wind movement is high) were largely of local origin in that section; and in eastern Kansas caused by strong northwest winds carrying dust from States to the northwest.

*Minneapolis, Minn.*—Following the great dust storm of November 12, 1933, over the Plains States and territory eastward, there were no such storms of importance in Minnesota until the latter half of January 1934. During the last decade of January unusually high winds prevailed and thick dust occurred on the 22d, 23d, 24th, 28th, and 31st. Thick dust occurred on six dates in February in southern counties. Unusually dry, windy weather during most of March favored dust storms which were of frequent occurrence. Thick dust occurred on 15 dates in southern and western counties. Weather conditions during April greatly favored dust storms, with unusually dry, windy weather prevailing during most of the month. Soil moisture was rapidly depleted, much new seeding was blown out of the ground, soil from plowed fields drifted badly, and considerable damage to growing crops resulted. Thick dust occurred on 19 dates. Unprecedentedly dry weather in May combined with frequent high winds greatly favored dust storms. Thick dust occurred on 8 days over the entire State. The climax of the dust storms prevalent so far this year was reached on May 9–10. Reports from over the State indicate that this storm was probably the most severe of its kind ever experienced. Much seed was uncovered or blown out, especially on light soils, where in extreme cases as much as 90 percent was reported lost.

*Des Moines, Iowa.*—November 12, 1933. This was probably the worst and most general dust storm in recent years and, according to the opinions of many, the worst dust storm ever to occur in Iowa. The air was not only filled with fine dust, but with debris of various kinds. At times objects could not be distinguished at a distance greater than 50 feet. This gale caused loss of lives and considerable destruction of property. Dust storms that began on the 18th continued until a wide-spread general storm occurred on the 23d.

*St. Louis, Mo.*—The term "dust storm" is entirely applicable to the conditions on November 12–13, 1933, April 10–11, April 22–24, and May 10–11, 1934, on account not only of the unusual thickness of the dust, but the brisk winds on those dates, which carried it to practically all parts of the State. Probably the dust storm of May 10–11 was the most severe, considering Missouri as a whole, but in some sections that of April 11, or April 23, was considered worse.

*Milwaukee, Wis.*—Dust reported on about 19 dates previous to May 1934. The worst dust storm of which there is any recollection in Wisconsin occurred on May 9–10, and covered the entire State. There were fresh to strong winds which drifted the soil in the fields and in places uncovered newly sown grains. By the morning of the 10th dense dust clouds covered the sky and this condition continued all day.

Some extracts from the station records show the progress of the May 9–12, 1934, dust storm eastward.

*Madison, Wis.*—The dust began to appear in the sky about 6:30 p. m., E. S. T., on May 9, and continued until after dark on the night of May 10–11.

*Dubuque, Iowa.*—Light dust began at 10:30 p. m. and continued until 9:30 a. m., May 11. Dense dust began at 11 p. m., May 9, and ended during the night of May 10. The minimum visibility was 800 feet.

*Keokuk, Iowa.*—A dust storm began in the afternoon of May 9 and continued through the 10th, 11th, and 12th. Visibility on the 10th was limited from 11 blocks to  $2\frac{1}{2}$  miles.

*Columbia, Mo.*—The air was quite murky on the 10th.

*Buffalo, N. Y.*—Dust was first noted at Buffalo Airport at the noon observation of May 10, 1934, due to the discoloration of a sprinkling rain which occurred at that time.

The visibility was 5 miles. From this time on dust of light intensity was recorded until 2 a. m. of May 11. The visibility was from  $1\frac{1}{2}$  miles to 5 miles during this period.

*Pittsburgh, Pa.*—The dust storm that was reported at several Western stations on the morning of May 10, 1934, was first observed in the vicinity of Pittsburgh as a peculiar pale yellow haze in the upper air about 6:15 p. m. of the 10th. At the airport station the dust was most dense at the 6 and 7 a. m. observations on the 11th when the visibility was reduced to 1 mile.

*Cincinnati, Ohio.*—First evidence of the Western dust storm reached Cincinnati shortly after noon on May 10. It was first observed on the hilltops at about 12:15 p. m., and at the Lunken Airport at 12:30 p. m. Visibility was greatly reduced, being only three-fourths of a mile from 2:30 p. m. to after 3 p. m.

*Nashville, Tenn.*—Visibility was less than 1 mile during the evening of the 10th and until 9 a. m. of the 11th at Nashville, and only one-fifth to one-fourth of a mile when the dust first appeared around 7 p. m. of the 10th.

*Springfield, Mo.*—Dust was reported on May 10. Visibility was reduced to one-half of a mile at times.

*Portland, Maine.*—The dust storm affected this vicinity on May 11, 1934, from 9:30 a. m. to 5:30 p. m. It began quite suddenly when the wind shifted from south to west and ended when the winds became west-northwest, shifting to northwest. Visibility was 1 mile at 2 p. m.

*Boston, Mass.*—A veil of dust appeared in the air shortly after day break on May 11 in New England and undoubtedly moved eastward over the ocean during that day. The dust was so fine that it appeared much as a high haze and was at an elevation of some 500 feet or more where visibility was reduced to a fraction of a mile, whereas visibility on the ground was up to 2 miles.

*New Haven, Conn.*—The sky became covered with dust at 9:30 a. m., May 11, which moved from the west and continued until shortly after 6 p. m. It was densest from 1 to 3 p. m. and reached close to the ground between these hours.

*Baltimore, Md.*—The dust was in the lower and upper atmosphere, within 2 to 3 miles of the earth's surface. In the lower atmosphere the density thickened after 8 a. m., May 11, at which time visibility was between 6 and 8 miles, decreasing to 1 and 2 miles between 10:30 a. m. and 2:30 p. m.

*Raleigh, N. C.*—Dust was first observed here at 2:40 p. m. on the 11th. Overhead there was only a hazy appearance, dust being observed mainly in looking toward the horizon. Dust seems to have disappeared or gradually withdrawn from most of the Piedmont on the 12th, but continued in the mountain region until the 14th.

*Atlanta, Ga.*—The second instance (referring to the dust storm of November 13, 1933) was observed in Georgia on May 11 and 12, 1934. In extreme northern Georgia the brightness of the sun was much reduced and mountains 10 miles away were cut off from view. In Atlanta the sky had a whitish appearance on the 12th.

*Vicksburg, Miss.*—May 11. Sun set yellow due to dust. Visibility  $2\frac{1}{2}$  miles in the west. Continued until 9 a. m. of the 13th.

*Charleston, S. C.*—Southerly winds on May 10 and 11 prevented the dust in the air over the central sections of the country from reaching this station, but on the 12th there was a sudden shift to northerly at 4:20 a. m. By 5:45 a. m. our airport station was reporting dust, and dustiness increased until 7:40 a. m., when the visibility had decreased to 4 miles.

*Savannah, Ga.*—On May 12 a hazy appearance of the sky was observed after 10 a. m., evidently due to dust. This was more noticeable in the afternoon, when visibility



Photographs through courtesy of Mrs. M. C. Jorgenson, Watertown, S. Dak.

FIGURE 1.—Dust storms in South Dakota, April 1934.

was reduced to 5 miles. It seemed to disappear at night-fall and was not again observed.

These extracts from station reports are intended to show the approximate maximum spread of the dust from day to day. The stations were chosen at the eastern limits of the phenomenon on the dates reported.

After May 1934 the extremely dry conditions that made such widespread dust storms possible began to be alleviated to some extent. Moderate to fairly generous rains were rather general over much of the region covered by the dry condition of the soil and, even where they were not sufficient to break the drought in a real sense, they were sufficiently heavy to lay the dust in many places and thus tended to a more stable soil condition.

## EFFECTS OF LOCAL SMOKE ON THE CLIMATE OF NASHVILLE, TENN.

By FOSTER V. JONES

[Weather Bureau, Nashville, Tenn., January 1935]

Few cities in the United States have a greater smoke nuisance to contend with during the winter months than Nashville, Tenn. Frequently during this season, dense smoke extending about 250 feet in height blankets the downtown section of the city for approximately a 4-mile radius from the Weather Bureau office. It has been so dense on occasions that the visibility was reduced to zero, the sun's disk invisible from street level, and street and automobile lights kept burning until after 10 a. m., although at the same time just outside the smoke area the sky and air were brilliantly clear.

The formation of this smoke shroud over the city is directly dependent on meteorological conditions, which when combined with local geographical features form a perfect union for stagnation of the lower atmosphere. Nashville is situated in a bowl completely surrounded by a rim of hills 300 or more feet high, and traversed diagonally by the Cumberland River. It has been observed that the smoke does not form when the wind velocity, as measured by the Weather Bureau anemometer 188 feet above the ground, exceeds 8 miles per hour. Velocities lower than 8 miles generally occur when a slow moving southeastern high overspreads Tennessee, at which time the wind lulls and the temperature falls rapidly to a critical point.

The only available records of the density of smoke at Nashville were made by R. M. Williamson during the several winters beginning 1927-28. The results were included in a paper read before the Tennessee Academy of Science and published later in the *Journal of the Tennessee Academy of Science*.<sup>1</sup> Williamson's statement in part is as follows:

The observations were made from the Weather Bureau office, in the Stahlman Building, and concerned the density of smoke as observed from that point, and at the hours 7 a. m., 9 a. m., 12 noon, and 4 p. m. Records were made during February and March each 4 years, December and January each 3 years, and November 2 years. Density was graded on the Ringelmann scale, as published and used by the United States Geological Survey. \* \* \* The following table gives the monthly averages for the 4 winters at the hours specified.

Month	7 a. m.	9 a. m.	12 noon	4 p. m.
November.....	2.0	1.5	1.0	1.2
December.....	2.3	2.1	1.5	1.4
January.....	2.1	1.9	1.5	1.2
February.....	2.1	1.8	1.2	1.1
March.....	1.3	1.0	0.4	0.2
Winter.....	2.0	1.7	1.1	1.0

<sup>1</sup> Williamson, R. M.—*Visibility, A New Element in Meteorological Observation*. (Read before the Tennessee Academy of Science, Nov. 26, 1932, and published in the *Journal of that society*.)

After May, while there were some dust storms, they were mostly moderate in character and were more or less local in extent. The reports of the various sections, as rendered to the Central Office, carry very few references to dust storms.

As a postscript to the above, it is interesting to note that the region mentioned as extremely dry in January continued so until the first of March, with severe dust storms reported throughout. The dust storms were rather widespread within the dry sections and became increasingly frequent toward the last of February and the first of March. Finally, they were of such intensity that appreciable dust was reported as far east as the Atlantic coast on March 6 or 7.

The percentages for the winter were, respectively, 40, 34, 22, 20.

These figures indicate the much greater prevalence of smoke in the early morning hours than in the afternoon. They show a gradual diminution of smoke from a maximum at about 7 a. m. to a minimum about the middle of the afternoon. This corresponds in a general way to the diurnal march of average wind velocity, for smokiness and wind velocity are very closely related. The density of smoke is, as a rule, in inverse proportion to the velocity of wind. It is least dense in the afternoon, at which time average wind velocities are highest. It is most dense in the early morning, for then the atmosphere is in its most quiescent state, unless, of course, there is active storm movement. Smoke will clear away often during times of rapidly rising temperature, due to turbulence in the atmosphere created by rising currents. The smoke is then lifted to elevations where it is carried away by the upper horizontal currents, while at the surface there may still be but little lateral movement. The presence of smoke in varying degree in different parts of the city, while dependent to some extent upon the number and size of the chimneys from which it comes, is also dependent upon the direction of the wind at the time. The detailed records show that there was some smoke nearly every day in the winter months, although there were several periods of 3 or 4 consecutive days when none was observed.

In addition to decreasing the visibility, the smoke layer holds the city minimum temperature considerably higher than that of the immediate vicinity. While there are many advantages in having a higher city temperature, there are many technical objections to this feature. The high downtown temperatures are those telegraphed and those upon which the local forecaster must base his forecasts and verification. It is also objectionable to give the public official temperatures, for the city as a whole, that are artificial, when the public knows from the freezing effects that the temperature must have been lower.

Some readers may think that a difference of a few degrees has little significance. In the Southern States the situation is quite different from that farther north, where freezes are almost a daily occurrence. Southern homes are not built to stand long spells of severe winter weather. Produce dealers often leave carloads of perishable goods unprotected. Farmers depend on temperatures near freezing for the killing of their winter meat supply. Therefore, a very definite critical temperature is reached at 32°, and continues down to 10°. These few degrees mean profit or loss and should be forecast as accurately as possible.

The attached graphs of the temperature, visibility, and wind velocity show the difference during the month of December 1934. There was no particular reason for choosing the month of December 1934, except that the data were more readily available and the work could be done from day to day; thus we have an arbitrary period in which typical effects are represented, although differences at this season are not nearly of so great a commercial